View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

Central Data System Concepts for Spacecraft Data Management

By RICHARD O. FIMMEL, ALEXANDER EGGER, and LOUIS M. BELLO
Richard O. Fimmel is in the Spacecraft Data Systems Branch, Ames Research Center, NASA, Moffett Field, California
Alexander Egger is Assistant Manager, Data Systems Electronics Department, TRW Systems, Redondo Beach, California
Louis M. Bello is a member of the Technical Staff, Data Systems Electronics Department, TRW Systems, Redondo Beach, California

SUMMARY

This paper discusses the design concepts of a central data system (CDS) for more efficient, flexible data management and its application in an advanced deep space solar probe. The design features high data sampling rates, programmable data processing, bulk data storage capability (for data sampled during periods of noncommunication), and standard experiment package/CDS interfaces. The basic system concept is based upon sampling each data point at a high rate in a fixed sequence and allowing a central processor to select, process, and format sampled data into a highly efficient format for transmission. The CDS is programmable so that data formatting and processing may be reprogrammed via the command link to optimize data transmission for unexpected conditions.

Preliminary design efforts have indicated that a CDS to process data from seven particle and fields experiments can be designed, using present state-of-the-art components, to weigh 16.5 lb and consume 5.4 watts (not including bulk data storage unit) from the DC/DC converter.

HC $3.00
MF .65

INTRODUCTION

Spacecraft for deep space missions are characterized by long term operational requirements and low telemetry transmission rates at the destination, as a result of both the large interplanetary distances involved and the limited transmitter power available. The highest data rate is needed at the destination to measure the planetary environment. A central data system which provides a wide variety of formats and on-board data processing makes possible efficient use of available telemetry bandwidth. A space vehicle used as a laboratory for the investigation of properties of interplanetary space and planetary environments may require transit times in the order of 18 months and additional operating time of 3 years. The long distances over which the spacecraft must operate, the unknown variations in the environment which may occur, and the duration of these flights make it necessary that the data processor be extremely adaptable and reliable. The adaptability should include provisions for accepting commands and program changes from earth to adjust the processes to match the environments encountered and to maintain a high transmission efficiency.

These facts point directly toward increased on-board data processing or higher telemetry rates or both. This paper presents the concepts developed for a programmable data management system (for use in a deep space probe) which has the capability to select and process scientific experiment data to maximize the utilization of the telemetry bandwidth.

The design was constrained to a spin-stabilized spacecraft communicating with the existing Deep Space Network operated by the Jet Propulsion Laboratory (JPL) for the National Aeronautics and Space Administration (NASA). Tracking time availability and command rate capability were considered. Standardization of interfaces between the experiment package and the CDS permits the number of experiments accommodated to be varied. This paper will consider seven particle and fields experiments.

The data processing capability of the CDS includes the seven basic functions of add, subtract, shift left, shift right, compare - greater than,

N68-14643 (ACCESSION NUMBER) (THRU)
17 (PAGES) 1 (CODE)
TMX-60801 (NASA CR OR TMX OR AD NUMBER) 07 (CATEGORY)
FACILITY FORM 602

less than and equal to stored limits. With these basic operations, algorithms can be written to perform most of the scientific data processing required. Although this system is more sophisticated than current spacecraft data processors, it must have equal reliability. This is achieved by providing the capability of reprogramming to bypass failed components. The CDS design described in this paper can be implemented with present state-of-the-art components.

The design offers great adaptability to a variety of missions and conditions by reprogramming or by altering the stored program via the command link. Additionally, the command processor, a part of the CDS, also decodes discrete commands for other subsystems.

DATA TYPES AND DATA LOADS

Many of the data-handling requirements are common to several experiments and are efficiently handled by the Central Data System. Since many experiments require identical processing, hardware redundancy is minimized by the common signal conditioning which permits the experiment/data system interface to be closer to the sensing device. Additionally, this alleviates the special signal-conditioning requirements within each experiment package to adapt the experiment to each specific spacecraft. Certain types of signals (e.g., low-level analog, high frequency, and narrow-pulsewidth signals) must be conditioned within the experiment because they do not lend themselves to routing through several feet of cable to a central point for processing. In addition to the scientific data inputs, the CDS handles the housekeeping data for both the spacecraft and the experiments. The solar-probe mission considered includes the following experiments: micrometeroid, fluxgate magnetometer, cosmic-ray detector, plasma probe, radio-propagation measurement, fast-neutron detector, and a very low-frequency measurement. Each experiment is briefly discussed below to define the interface, data rates, and special processing required. Details of the experiment are presented in reference 1.

Micrometeoroid Experiment

The micrometeoroid experiment measures the flux, momentum, energy, and spatial variation in the flux of the minute particles found in the interplanetary space. Since the events range from 10 to 100 impacts/day, the data rate is approximately 0.1 bps. The data are asynchronous, not geared to spacecraft spin, and, therefore, only sampled during an event. The measured parameters are particle velocity, direction, and energy. Most of the processing is performed within the experiment package because of the low-level signals and because of the need to reduce and standardize interfaces with the CDS.

Magnetometer

This experiment measures the steady-state and transient characteristics of the magnetic field associated with the solar wind as a function of the radial distance from the sun. These analog signals are processed by the CDS. Data sampling is geared to spacecraft spin, and the expected data rates are 128 bps. Averaging techniques may be used to reduce the data rates.

Cosmic-Ray Detector

This experiment measures the energy spectrum, angular distribution, composition, and time fluctuation of the protons, electrons, and alpha particles originating from both the sun and the galaxy. Because of the high-frequency nature of the experiment data, certain logical functions are performed within the experiment. The output data to be processed by the CDS are basically pulses to be counted and analyzed for pulse height. The data sampling is geared to the spacecraft spin. The expected data rate is 74 bps. Logarithmic compression can be performed by the CDS to reduce data rates.

Plasma Probe

This experiment measures the energy distribution, directional distribution, and the spatial and temporal variations of the ion and electron components of the interplanetary plasma. The analog data output is processed by the CDS. Data sampling is geared to the spacecraft spin and the expected data rates are 129 bps. The CDS can calculate the minimum and maximum values to reduce the data rates.

Radio Propagation Measurement

This experiment measures the average interplanetary electron density between the earth and the probe and time variations of this quantity. Since the sensor is essentially an antenna, the experiment package contains the signal-conditioning circuitry, such as a receiver, demodulator, and filter. Both analog and digital outputs are received by the CDS and sampled synchronously with spacecraft spin. The data rate is 228 bps. The CDS can reduce this rate by calculating the minimum and maximum value of the experimental data.

Fast Neutron Detector

This experiment, activated during solar prominences, measures the flux and energy spectrum of solar neutrons in the energy range from 1 to 20 Mev. The data rate during this solar flare is 225 bps. The experiment data are asynchronous with the spacecraft spin; data are stored within the CDS during a period of 1 hour and transmitted at a low rate over a period of 24 hours. The data consist of pulses which are counted and analyzed for pulse height by the CDS.

Very Low Frequency

This experiment investigates the mechanism which binds the collisionless solar wind into a fluid. The basic sensor for this experiment is an antenna. Consequently, signal conditioning is performed within the experiment package to provide electric and magnetic field information in the form of analog data. Data sampling is geared to the spacecraft spin and the expected data rate is 51 bps.

CENTRAL DATA SYSTEM CONCEPTS

The objective of the CDS for deep space probes is to provide a programmable data management system to select and process experiment sensor data into a highly efficient format for transmission. The basic concepts developed to achieve the objectives of the CDS are summarized in the following paragraphs.

Modes of Operation

Eight basic modes of operation appear to satisfy the needs of a deep-space probe and provide the project manager with needed flexibility to meet varying mission requirements. Five of these modes are programmable and three are fixed. The programmable modes are:

- Transmission of real-time data interleaved with stored data
- Transmission of real-time data only
- Transmission of high-rate engineering data only
- Self-test mode
- Data-store mode

The fixed modes of operation are:

- Processor program verification (contents of program memory are transmitted to ground)
- Fixed real-time transmission (limited capability) synchronized by either actual or simulated sun pulse
- Stored data transmission only

Input Data Sampling

Each data point is sampled at a fixed high rate and is processed and formatted by a programmable central processor. This approach frees the processor from the necessity of frequent program interrupts to sample data, thereby reducing both speed and power requirements of the processor. The CDS samples synchronous data, geared to spacecraft spin rate, and asynchronous data. Asynchronous data are formatted and transmitted only when an event occurs and are interleaved with synchronous data.

Data Processing

The CDS can process and compress sampled data into an efficient format for transmission. Data processing capabilities include algorithms, such as logarithmic data compression, determining minimum and maximum values of "n" number of data samples, and averaging data samples.

Command Processing

A command processor, independent of the data processor, decodes discrete commands and processor program instructions. All transmitted commands are self-verified prior to execution. This independent command processor is used within the CDS to enhance system reliability. For example, if the central processor program becomes inoperative, it is essential to have the capability for reloading the program memory via the command link independently of the processor.

Flexible Telemetry Format

Telemetry rates of deep-space probes are low and it is therefore important to utilize the available telemetry bandwidth efficiently. A flexible format is essential to assure effective utilization of telemetry and avoid fill-in bits.

Elapsed Time

The CDS is designed with a central elapsed-time clock. The elapsed-time clock has a resolution of 1 second with a long-term stability within

±0.01 percent for a 2-year period and has a recycling time of approximately 194 days. Elapsed time is transmitted within each frame to provide adequate data correlation with elapsed time under all modes of operation.

Bulk Data Storage Capability

A bulk data store is provided on board the spacecraft for storing data during noncommunication periods. The use of the bulk store will become more important as the communication periods with the DSN become less available as more spacecraft are launched. The CDS processes and formats the data prior to placing it into bulk data storage so that it is ready for direct playback when communications are reestablished.

Stored/Real-Time Telemetry Interlace

Since there will probably be prolonged periods of data storage during noncommunication with the spacecraft, the ability to interlace stored data with real-time data is essential. With an interlace capability, uniform data samples can be transmitted throughout the mission at each bit rate. It is entirely possible that the amount of ground station time to track the spacecraft can vary from 8 to 10 hr/day to as little as 8 to 10 hr/week. The Central Data System must provide reasonably uniform data coverage under these circumstances. More storage capacity is required when tracking time is reduced; therefore, interleaving stored with real-time data will result in greater spacing between real-time data samples.

Standardized Experiment/CDS Interfaces

Flexibility is basic to any stored program system. Consequently, for a central data system to maintain this flexibility, it is essential that experiment/data system interfaces be standardized to avoid expensive redesign as various experiments or missions are considered. The CDS utilizes three basic input signal interfaces. These are: pulse data (counting), analog signals, and bilevels (status signals). Pulse data are either pulse/height analyzed or counted.

These basic concepts make possible a system design with optimum operational flexibility. They provide system flexibility from mission to mission by utilizing standard equipment interfaces and programmable operation. Also, the capability for inflight program modification is provided to optimize system operation and to meet changing conditions and data requirements.

CENTRAL DATA SYSTEM DESCRIPTION

A simplified block diagram of the CDS is shown in Figure 1. (See references 2 and 3 for detailed diagrams.) The solid lines in the figure illustrate data flow; the dotted lines illustrate control signals.

The basic CDS design consists of the following elements:

- Input data sampler (IDS)
- Input data buffer (IDB)
- Data processor
- Output buffer (OB)
- Fixed real-time transmission logic
- Coding logic
- Command processor
- Bulk data store unit (not included in weight and power estimates)

The CDS samples input data from experiment packages and from spacecraft performance sensors in the form of three basic types of signals (analog, pulse, and bilevel data). All analog data are encoded to 8-bit accuracy by one-time shared analog-to-digital converter.

Each synchronous data source, dependent upon spacecraft rotation, is sampled 64 times per spacecraft revolution and stored for processing by the data processor. The processor selects the desired samples from the IDB, performs the required data compression (e.g., log scaling, minimum-maximum determination, averaging, etc.), and formats the processed data for transmission. All processor operations are controlled by a stored program. The size of the output format is programmable to permit efficient telemetry utilization at each data bit rate.

The CDS timing and synchronization has been designed to provide an input data sampler that operates essentially independently of transmission link requirements. That is, experiment data are sampled by the IDS and stored within the IDB until the processor is ready to select data for processing. The processed data are formatted and placed into one of the two output buffers for transmission. The only timing requirement is that data must be processed at a high enough rate to ensure sufficient data being available for continuous uninterrupted transmission.

Since the data are processed prior to transmission, data are sampled independently of transmission link requirements. For example, as the allowable transmission bit rate decreases as the earth-spacecraft distance increases, the processor will select fewer samples to be transmitted per spacecraft revolution. Also, data compression will further reduce the data transmission requirements.

Modes of Operation

The CDS has five programmable modes of operation (Figure 2). Only one mode is operable at any given time. The real-time data interleaved with stored data refers to the operation in which the spacecraft is in communication with the DSN. During this time, the CDS will alternately transmit real-time data and stored data (from the bulk store unit) on a frame basis. A real-time-data-only mode is provided to transmit only real-time data at twice the data rate of the real-time/bulk-store mode. The data store mode refers to storing data into the bulk store. High-rate engineering-only mode refers to the transmission of spacecraft performance and experiment status data at a high rate during launch phases or during times of suspected spacecraft malfunction. A self-test mode is provided to evaluate CDS performance during the course of the mission.

Each of the five programmable modes requires an individual program; however, common subroutines are shared among all programs. That is, one bank of the processor program memory contains subroutines and the other bank contains the main programs. The main program branches off into a subroutine whenever one is required; after the subroutine is performed the main program is continued.

The three fixed modes of operation are designed to bypass the processor. They are used to transmit a limited quantity of scientific and engineering data during periods when the processor program is being modified or verified and during times when a processor malfunction is suspected. The input data sampler operates in its normal sequence during this mode. However, instead of the processor selecting data samples from the IDB, a fixed programmer selects them as shown in Figure 1. The selected data are directly formatted by the fixed real-time transmission logic and are fed to either the coding circuitry or directly to the transmitter. The real-time transmission mode provides minimal scientific data during periods of processor reprogramming or in the event of processor failure.

Input Data Sampling

A fixed programmer provides control signals required to sample all data inputs in a fixed sequence. Bilevel data are sampled and stored directly into the IDB. Analog data are sampled and encoded into an 8-bit binary number for entry into the IDB. Pulse data are first accumulated within counters and then sampled and stored within the IDB.

All synchronous data are sampled 64 times per spacecraft revolution. This is accomplished by dividing each spacecraft revolution into 64 equal segments called sectors. Each sector is also divided into 64 segments called words.

Figure 3 illustrates the characteristics of a single spacecraft sector. As shown, analog inputs are sampled, encoded, and stored within the IDB during word times 1 through 20. Pulse data are sampled for one sector and stored within the IDB during word times 21 through 34. Low-rate data are sampled once per spacecraft revolution in word 35. Subcommutated data are sampled once per 64 spacecraft revolutions in word 36. Spare words are provided for growth capability and to accommodate small changes in spin rate.

Data Processing

Data processing is defined as those operations performed on sampled data by the processor prior to transmission. Processing operations include:

- Selection of specific data from the IDB and the auxiliary memory
- Data compression
- Data formatting

These operations are programmable and are under the control of a processor instruction memory.

The processor is capable of performing specific data compression. The operations include log scaling, averaging, determining minimum and maximum values of n samples, and any other data operation which can be performed by basic addition, subtraction, and shifting left and right, etc. At lower bit rates, the processor will reduce the number of bits per frame by selecting fewer samples per spacecraft revolution and by performing more data compression such as log scaling data, finding minimum and maximum values, etc. The processed data are automatically formatted as they are transferred from the processor to the output buffers. During the transfer operation, the processor will perform the following formatting steps:

1) Select the frame synchronization bits from the processor instruction momory and enter them into the appropriate output buffer memory locations.
2) Enter subcommutator, bit rate, and format identification into appropriate output buffer locations.
3) Store processed data into programmed output buffer locations. Store sector identification bits to identify data with its sector sampling address where required, i.e., minimum-maximum.
4) Determine the size of each frame according to the processor program.
5) Format and store each frame of data to permit continual uninterrupted real-time transmission of data alternately from the two output buffers.

A typical processor program flow diagram is shown in Figure 4. A typical format for 1024 bps transmission rate is shown in Figure 5. This is one example of many formats which are possible by programming. The format is divided into four basic sections:

- Frame identification
- High-rate data
- Low-rate data
- Subcommutated data

The resultant frame size for the example format (Figure 5) is 1087 bits. The frame sizes are programmable and any practical frame size may be used for each of the eight transmission bit rates. Typically, frame sizes on the order of 512 to 1200 bits can be used for the CDS. The only criterion is that, whatever frame size is chosen for a given transmission bit rate, a complete frame of data must be processed, formatted, and stored within the output buffer in time for continuous uninterrupted transmission.

Table 1 lists the processing algorithms and total transmission bits for each experiment for the eight transmission bit rates. Various formats can be derived from Table 1. A format ID identifies all formats for the CDS modes of operation shown in Figure 5.

Input Data Buffer

Two IDBs permit data to be sampled during each spacecraft revolution. That is, one IDB is being filled while data are being extracted from the other IDB for processing. Both IDBs are used during the real-time scientific "only" mode. This procedure also provides for a partially redundant mode of operation to increase system reliability. That is, a special mode may be commanded which will bypass one of the two IDBs. Data will then be entered into the one selected IDB during one spacecraft revolution and read out for processing during the next.

Output Buffer

Two output buffers are used to avoid time-sharing problems associated between write-in and readout of data, and to minimize circuit complexity. The processor can then perform its operations asynchronously and avoid the severe constraint of time-sharing the output buffers. Thus, the processor loads data into one output buffer while the other is being read out for real-time transmission.

Each output buffer has a capacity of 1200 bits. The size of each frame, however, is programmable by the processor. The processor can store more than one frame of data into an output buffer. This may occur at the lower transmission bit rates where the frame size is approximately 246 bits.

Command Processor

The command processor receives transmission commands from the ground tracking stations to control various spacecraft operations. The command processor:

1) Accepts a serial data train from ground stations up to a frequency of 1 kHz.
2) Accepts, verifies, and decodes transmitted discrete commands:
    - 35 for the CDS
    - 27 for the experiment sensors
    - 22 for other spacecraft subsystems
3) Reprograms processor instruction memory, verifying each instruction prior to entering it into the processor memory.

The philosophy adopted for verifying commands prior to execution by the CDS provides multiple checks (i.e., parity, complement, and duplication) on-board the spacecraft in lieu of transmitting each command to the ground station for verification. This philosophy has been adopted because of the extensive time required for communication between the DSN and the spacecraft. For example, at a distance of 2 AU approximately 32 minutes is required to transmit a command to the spacecraft and receive a verification signal back.

Bulk Store

The bulk store is used to store processed data during periods of non-communication with the DSN. Data are processed, formatted, and stored within the bulk store at the prevailing transmission bit rate.

When communication is reestablished, stored data are transmitted with real-time data on an alternating frame basis. For example, if the communication period is a maximum of 11 hr/day, 11 hours of real-time data will be transmitted with as much as 13 hours of stored data. The data stored over the 13-hour period are reduced by the processor so that it can be transmitted over a period of 11 hours interleaved with 11 hours of real-time data. The usable storage capacity is 2×10^7 bits at 512 bps. Based on the present state of the art, storage capacity can be provided by a tape 4316 feet long which includes gaps for properly timing the interleaving.

Typically, interleaving is achieved by allowing the processor to load one frame of processed real-time data into an output buffer and one frame of stored data from the bulk store within 1 second. That is, during the interleaving mode of transmission, each output buffer is loaded with one frame of real-time data and one frame of bulk store data. Figure 6 illustrates the timing relationship between processing and transmitting of data in this mode of operation. At the highest transmission bit rate, the real-time data frame and the bulk-store data frame consist of approximately 512 bits each. This means that 1024 bits of data are transmitted from each output buffer every second.

Timing gaps are provided (Figure 6) to reduce the accuracy requirements of the tape-speed control loop. The tape speed is synchronized to the frame rate of the output buffers by use of a proportional control servo loop.

Convolutional Coding

Convolutional coding with sequential decoding can be used to improve the telemetry link performance in terms of reducing the undetected error rate and increasing the data rate. Such a technique has been developed at Ames Research Center and is being implemented for future Pioneer spacecraft missions.

A coding gain of 5.6 to 6.6 db is achievable over no coding. This is a 3 to 4 db gain over simple parity check codes such as used in the Pioneer VI and VII spacecraft data systems.

CDS Self Test

A self-test routine within the processor instruction memory may be called upon automatically, perhaps at daily intervals, to evaluate the performance of the CDS. A special routine will check offset and calibration of the experiments; another routine will test A/D converter accuracy by encoding three known voltages and comparing them against stored limits. The data operator will be checked for proper addition, subtraction, shifting, etc.

The results from each test may be transmitted to the ground or a simple test OK code may be transmitted for the entire self-test routine within the subcommutator.

Processor Memory Parity Check

The processor memory is checked for parity each time an instruction is read. If a parity error occurs, the CDS automatically enters the fixed real-time transmission mode which will completely bypass the processor. The ground station is notified via the real-time transmission that a parity error has occurred. The ground station may then command switching to a redundant processor instruction memory or a program verification mode may be commanded where the contents of the program in use are transmitted to the ground. If only a few commands are in error, they may be re-entered into the processor instruction memory via uplink transmission thereby saving the time required to reload the entire program.

Transmission Bit Rate Selection

The CDS can transmit data at eight bit rates: 2048, 1024, 512, 246, 128, 64, 32, and 16 bps. At the present time, three programs will be used to process data at the different transmission bit rates. For example, one program may perform processing at 2048 and 1024 bps, a second program at 512, 256, and 128 bps, and third program at 64, 32, and 16 bps. The programs are not exclusively for one set of transmission bit rates. For example, the processor program normally allocated for the 1024 bps transmission rate can be used at the lower bit rate of 64 bps. However, with this combination, 16 spacecraft revolutions may be required to transmit one frame of data.

Weight and Power Summary

A preliminary design of the CDS, based upon available low-power integrated circuit logic, results in a total weight of 16.5 lb consuming 5.4 watts of power from the DC/DC converter.

Weight and power calculations for the CDS memories are based on the use of core systems with operating speeds up to 4600 memory cycles per second.

CONCLUSIONS

This study has shown that fixed input data sampling is important to free the Central Processor from the burden of frequent program interrupts; command processing must be independent of the Stored Program Central Processor; uniform data coverage, for each respective bit rate, can be provided by the proper use of a bulk data store on board the spacecraft and then interlacing stored data with real-time data during periods of communication with the spacecraft; up to eight modes of operation are required to furnish the program manager with the needed flexibility to meet varying mission and data requirements; and that a flexible data format is essential to make optimum use of the limited telemetry capability on deep-space missions. Therefore, the resultant CDS design provides a system for many missions with only a one-time development and qualification cost.

The system described can be termed a third-generation spacecraft data system. (The first-generation systems were hardwired, fixed-format systems; and the second generation utilizes flexible-format capabilities on board the spacecraft which can be altered from the ground via command link.) The CDS concepts and designs described offer great flexibility under the control of the stored program which may be altered via the command link. A fourth-generation spacecraft data system probably will incorporate most or all of the third-generation capability along with programming or hardware capabilities that allow the system to be self-adaptive. These systems will have primary importance when the command capability diminishes drastically because of the increased distances involved.

Although only seven basic types of experiments applicable to a solar probe were considered, other types of experiments or instruments could yield valuable information. For example, taking TV pictures of the other side of the sun and transmitting to the earth information indicating the sun spot and solar flare activity could aid in developing techniques for predicting solar activity. Such techniques could become extremely important as space travel increases, insofar as they would make possible more accurate prediction of solar storms. The CDS could accommodate data from such a TV system by increasing the memory size and processing capability. New sensors can be readily accommodated by the CDS as they become available because of the concept of a standard interface between the CDS and experiment packages.

REFERENCES

1. Egger, Alexander; Sanders, Nathanial; and Bello, Louis: Research Report, A Study to Determine an Efficient Data Format and Data System for a Lightweight Deep Space Probe. NASA CR-73083, 1966.

2. Egger, Alexander and Bello, Louis: Final Report, A Study to Determine an Efficient Data Format and Data System for a Lightweight Deep Space Probe. NASA CR-73084, 1966.

3. Egger, Alexander and Bello, Louis: Summary Final Report, A Study to Determine an Efficient Data Format and Data System for a Lightweight Deep Space Prove. NASA CR-73085, 1966.

FIGURE CAPTIONS

Fig. 1 - Simplified CDS block diagram.

Fig. 2 - CDS modes of operation.

Fig. 3 - Spacecraft sector detail diagram.

Fig. 4 - Flow diagram of processing and formatting operation.

Fig. 5 - Typical format.

Fig. 6 - Processor timing for transmission of real-time data interleaved with bulk store data.

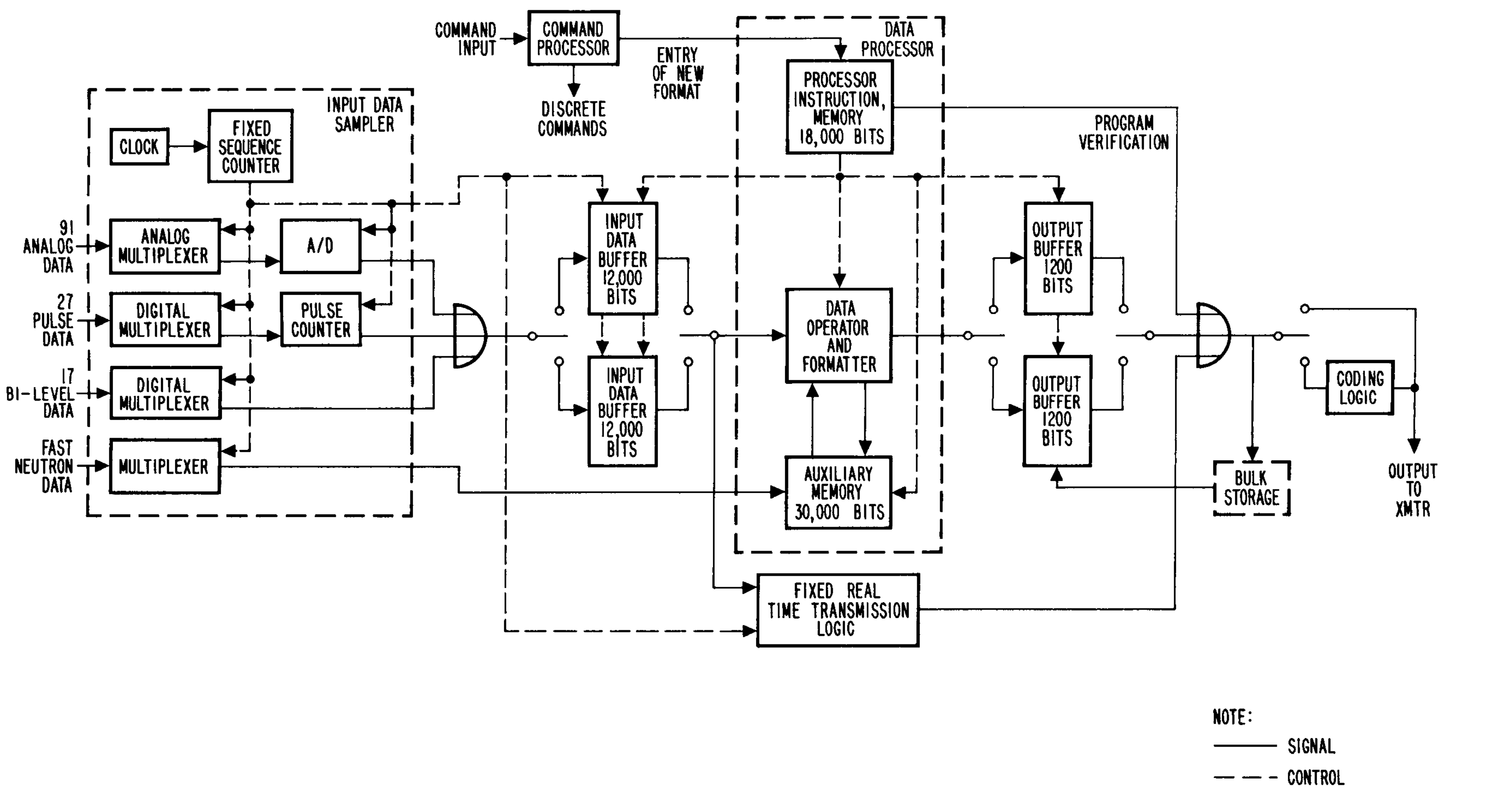


Fig. 1 - Simplified CDS block diagram.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

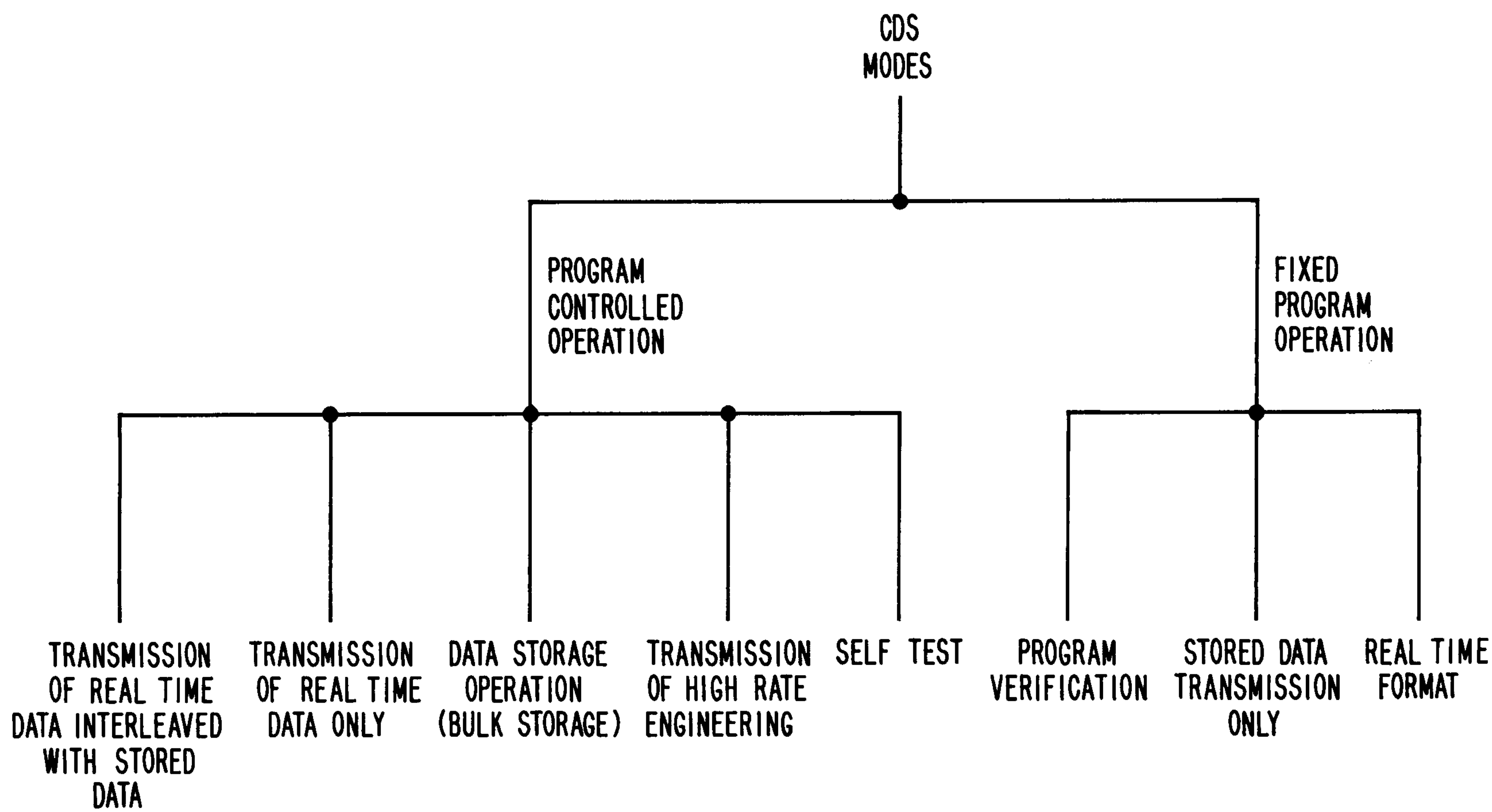


Fig. 2 - CDS modes of operation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

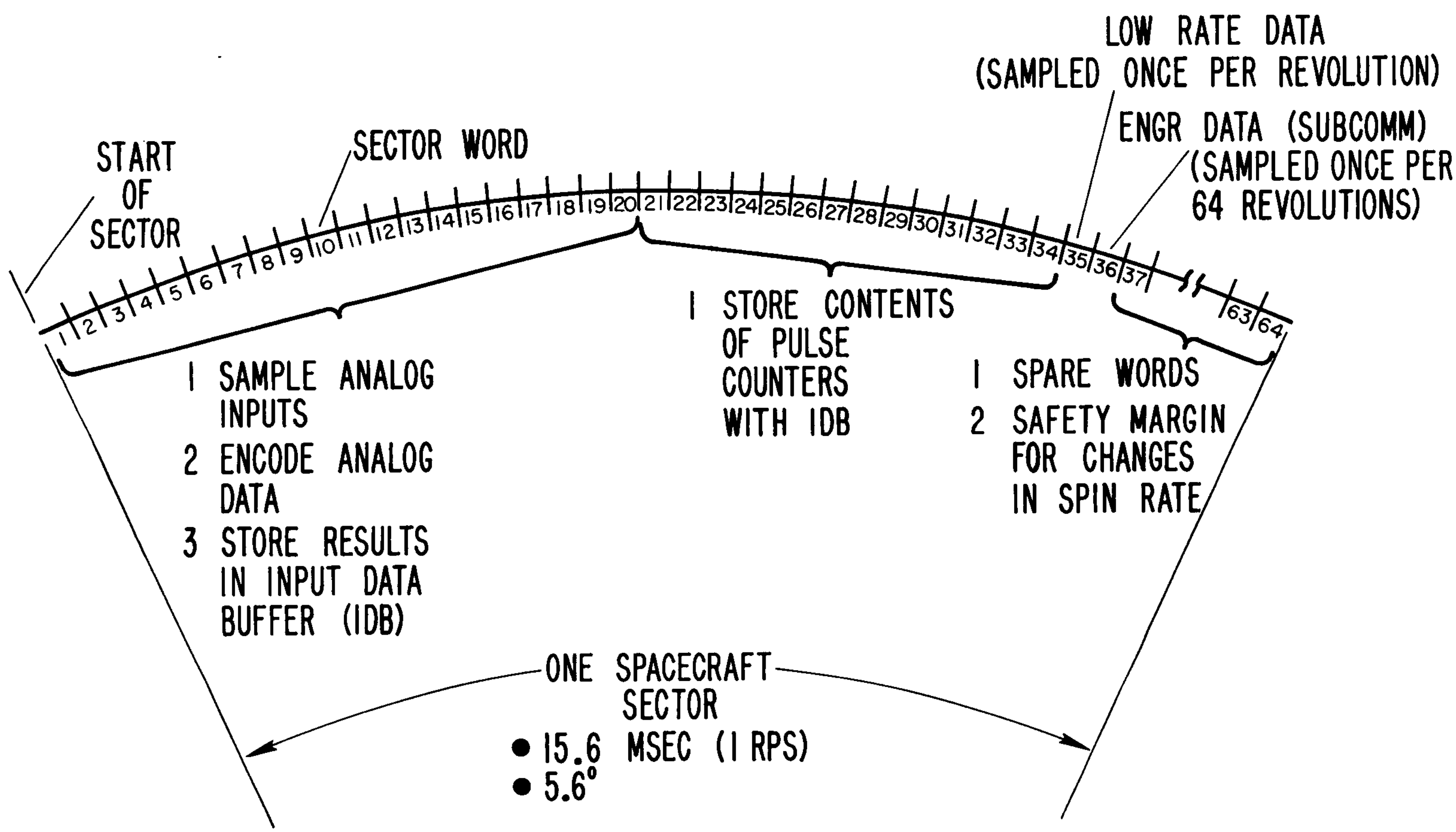


Fig. 3 - Spacecraft sector detail diagram.

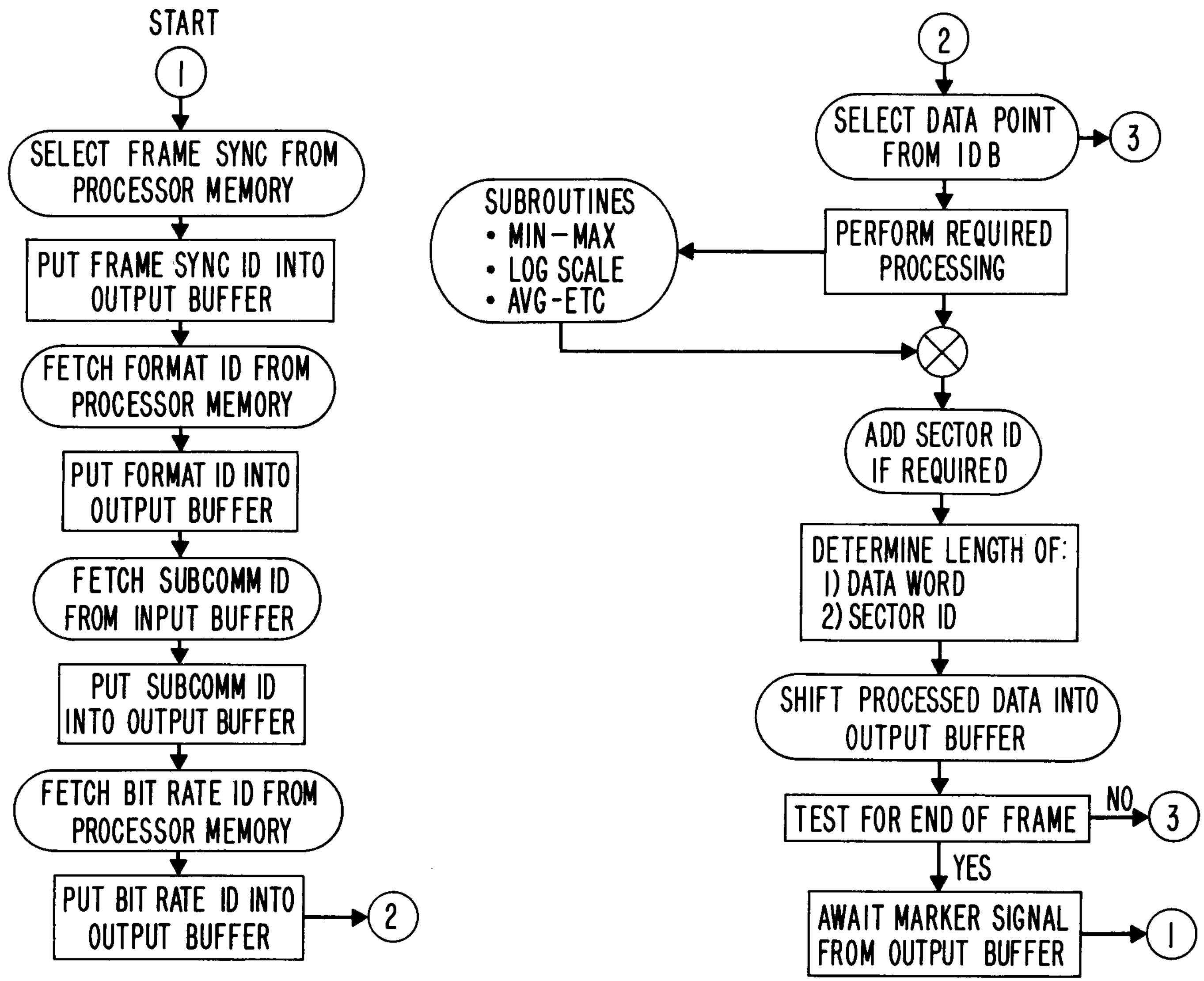


Fig. 4 - Flow diagram of processing and formatting operation.

FRAME IDENTIFICATION				HIGH RATE DATA					
FRAME SYNCH	SUB-COMM ID	FORMAT ID	BIT RATE	MAG	C COS	PLA	RAP	VLF	W COS
24 BITS	6 BITS	4 BITS	3 BITS	192 BITS	312 BITS	125 BITS	112 BITS	24 BITS	213 BITS

NOTE:

PLA	PLASMA
MIC	MICROMETEROID
VLF	VERY LOW FREQUENCY
RAP	RADIO PROPAGATION
MAG	MAGNETOMETER
MOM	MOMENTUM
TOF	TIME OF FLIGHT
C COS	CHICAGO COSMIC RAY
ET	ELAPSED TIME
ωt	SPIN RATE
TOTAL BITS	1087 BITS

* MIC DATA REPLACES VLF DATA WHEN A MIC EVENT OCCURS

** FAN DATA REPLACES RAP DATA WHEN FAST NEUTRON IS ACTIVE

LOW RATE DATA 64 BITS

START TIME OF SAMPLING CYCLE (ET_1)	8
START SECTOR ADDRESS OF SAMPLING CYCLE	8
PLASMA VOLTAGE & CHANNEL ID	8
EXP NORMAL CALIBRATE STATUS MIC, RAP, VLF & FAN ID	6
BITS	30

MIC*	
A&B MATRIX	8
ENERGY & MOM	8
TOF	4
SUN ASPECT	7
A, B & M	3
EVENTS	
MIC ELAPSED TIME	4
BITS	34

RAP**	
S_1	10
S_2	6
S_3	6
S_4	6
S_6	6
BITS	34

FAN**
BLOCK OF 34 BITS

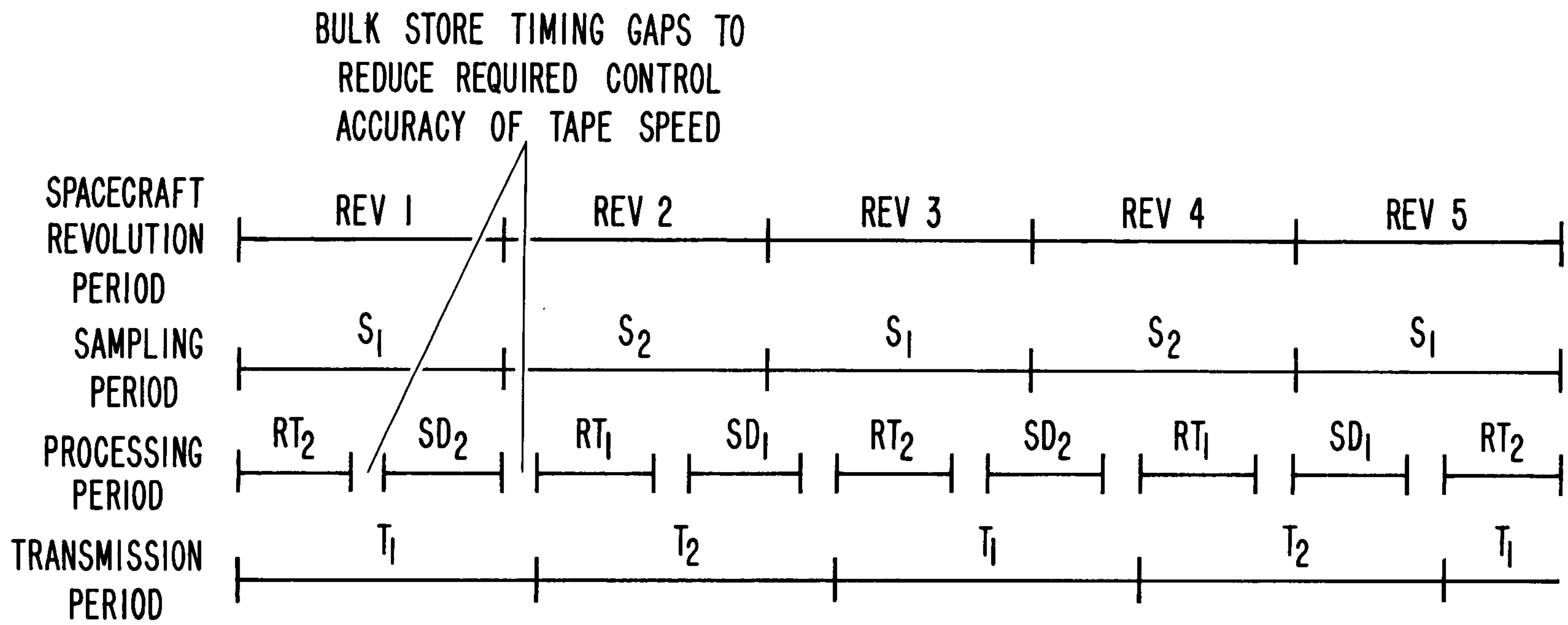
VLF*	
X_c	6
Y_c	6
Z_c	6
M_1	6
M_2	6
FILTER	4
BITS	34

SUB COMM (8/BITS/FRAME)

ENG DATA - 48 WORDS
BI-LEVEL - 2 WORDS
INCLUDES
ET_2 (ONE WORD)
ωt (ONE WORD)
MAG (ONE WORD)
RANGE
OFFSET
ORIENTATION
ET_3

54 8-BIT WORDS

Fig. 5 - Typical formats.



S_1 = SAMPLE AND STORE DATA INTO IDB 1
S_2 = SAMPLE AND STORE DATA INTO IDB 2
RT_1 = PROCESS REAL TIME DATA FROM IDB 1 AND LOAD INTO OUTPUT BUFFER 1
RT_2 = PROCESS REAL TIME DATA FROM IDB 2 AND LOAD INTO OUTPUT BUFFER 2
SD_1 = LOAD BULK STORE DATA INTO OUTPUT BUFFER 1
SD_2 = LOAD BULK STORE DATA INTO OUTPUT BUFFER 2
T_1 = TRANSMIT FROM OUTPUT BUFFER 1
T_2 = TRANSMIT FROM OUTPUT BUFFER 2

Fig. 6 - Processor timing for transmission of real-time data interleaved with bulk store data.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

TABLE I. EXPERIMENT PROCESSING ALGORITHMS AND DATA BITS

	2048 1024 Bit Rates		512 256 Bit Rates 128		64 32 Bit Rates 16	
Experiment	Algorithms	Bits Per Frame	Algorithms	Bits Per Frame	Algorithms	Bits Per Frame
Magnetometer	Select eight samples per rev	192	Select four samples per rev	96	Selected one sample per rev	24
Chicago cosmic ray	Select four samples per rev +16 sector ID bits. Sample subsequent sectors each sampling period.	312	Select two samples per rev +8 sector ID bits. Sample subsequent sectors each sampling period.	164	Select one sample per rev log scale, 4 sector ID bits required. Sample subsequent sectors each sampling period.	65
Plasma probe	Select 16 samples per rev +13 bits for max flux	125	Select four samples per S/C rev +13 bits for max flux	41	Select one sample. Determine max value of flux	20
Radio propagation	Select 16 samples per sec	112	Calculate min-max value	24	Calculate min-max value	24
Very low frequency	Select one sample	24	Select one sample	18	Select one sample	18
Webber cosmic ray	Select four samples per rev, log scale, trans 16 sector bits. Sample subsequent sectors each sampling period.	213	Select two samples per rev, log scale, trans 8 sector bits. Sample subsequent sectors each sampling period.	156	Select one sample per rev, log scale, trans 4 sector bits. Sample subsequent sectors each sampling period.	78
Micro-meteoroid	Transmit 34 bits only when event occurs in low rate data group.	34*	Transmit 34 bits only when event occurs in low rate data group.	34*	Transmit 34 bits only when event occurs in low rate data group.	34*
Fast neutron	Collect data for one hour 20,700 bits and transmit in 34-bit blocks in low rate data group.	34*	Collect data for one hour 20,700 bits and transmit in 34-bit blocks in low rate data group.	34*	Collect data for one hour 20,700 bits and transmit in 34-bit blocks in low rate data group.	34*
Low rate data	See Figure 5.	64	See Figure 5.	64	See Figure 5.	64
Subcomm	See Figure 5.	8	See Figure 5.	8	See Figure 5.	8
TOTAL		1050		571		301

*These data bits contained within 64 low rate data bits.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA